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THE WATER SUPPLIES OF INTERSTATE COMMON CARRIERS ON THE GREAT LAKES[1]

By H. P. Letton

The fact that drinking water supplies on board lake vessels were often contaminated and that such contamination undoubtedly caused a marked increase in the typhoid rate among sailors was pointed out as early as 1909 by Cobb. The matter was also discussed by Young in 1910, and deValin in 1914. It was not, however, until the Interstate Quarantine Regulations were amended so as to put the control of drinking water supplies aboard interstate common carriers under the supervision of the United States Public Health Service that any active measures were taken towards bettering conditions.

The Interstate Quarantine Regulations provide that all drinking water furnished for use of crews or passengers on any common carriers engaged in interstate traffic shall conform to a bacteriological standard promulgated by the Secretary of the Treasury. This standard has been discussed before the American Water Works Association by Monfort, Bartow and others. Briefly, the standard requires that the total number of bacteria on agar at 37°C. shall not exceed one hundred per cubic centimeter, and not more than one out of five 10 cc. portions of any sample examined shall show the presence of organisms of the bacillus coli group.

Following the promulgation of the Interstate Quarantine Laws and Regulations relating to common carriers and in order to facilitate their enforcement, the Continental United States was divided into twelve districts, known as Interstate Sanitary Districts (see fig. 1). The District of the Great Lakes embraces parts of the States of New York, Pennsylvania, West Virginia, Indiana, Ohio, Illinois, Wisconsin and Minnesota, and the entire State of Michigan.

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[1] This paper is an abstract of an advance copy of a report on the operations of the Sanitary District of the Great Lakes during the past season. The report is the joint authorship of Surgeon J. O. Cobb, Assistant Surgeon C. L. Williams, and the speaker, all of the United States Public Health Service. Presented at meeting of the Illinois Section, January 25, 1916.

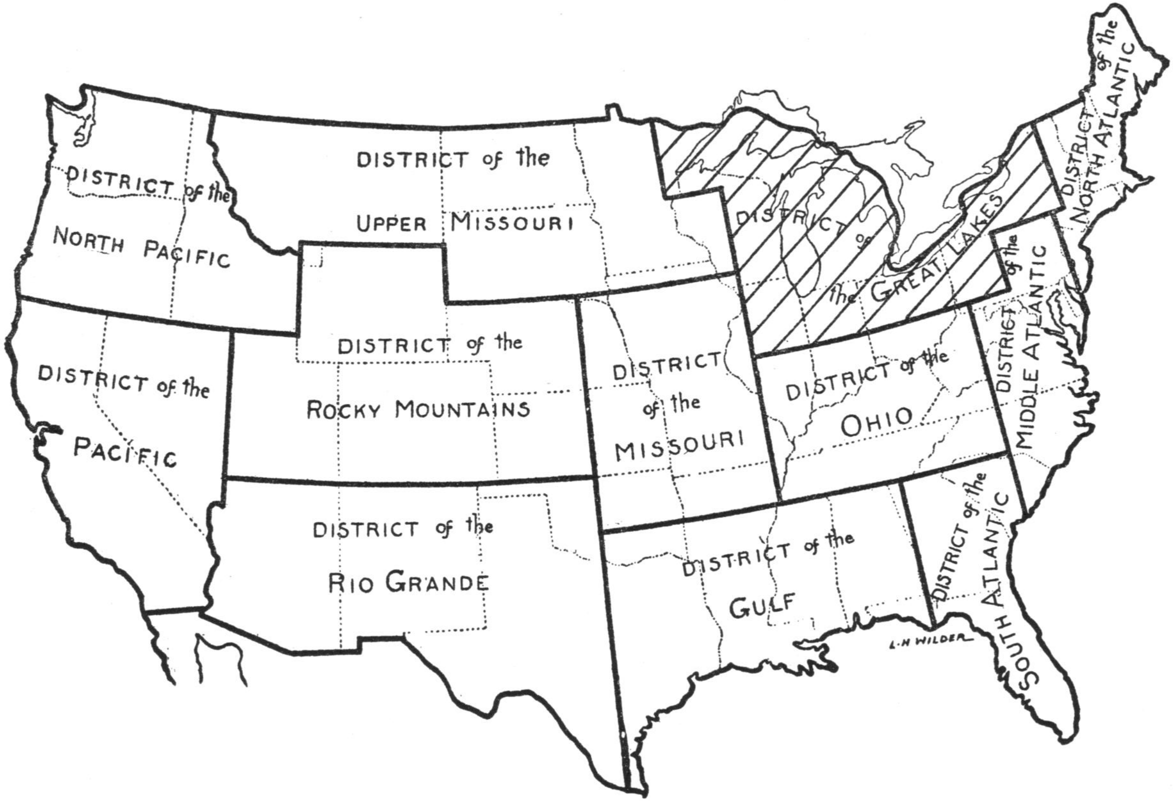
DISTRICT of the NORTH PACIFIC
DISTRICT of the UPPER MISSOURI
DISTRICT of the GREAT LAKES
DISTRICT of the NORTH ATLANTIC
DISTRICT of the PACIFIC
DISTRICT of the ROCKY MOUNTAINS
DISTRICT of the MISSOURI
DISTRICT of the OHIO
DISTRICT of the MIDDLE ATLANTIC
DISTRICT of the RIO GRANDE
DISTRICT of the GULF
DISTRICT of the SOUTH ATLANTIC
L.H. WILDER

FIG. 1. MAP SHOWING INTERSTATE SANITARY DISTRICTS, DISTRICT OF GREAT LAKES CROSS HATCHED

The headquarters and laboratory for this District are at the United States Marine Hospital, 4141 Clarendon Avenue, Chicago, Illinois. The work is under the direct charge of Surgeon J. O. Cobb, United States Public Health Service.

While the regulations apply to both vessels and trains, during the past summer no attempt was made to study the train waters in this District, all the energy being directed towards a solution of the ship problem. Inspections were made and samples collected from most of the passenger vessels and from some freight vessels on the Great Lakes. The scope of this work will be briefly outlined.

PRESENT METHOD OF OBTAINING DRINKING WATER ON LAKE VESSELS

There are two general methods of obtaining drinking water on board lake vessels, the first and most common being by pumping or by gravity through a seacock in the hull of the vessel, and the second by filling the drinking water tanks through a hose from a hydrant on shore. The seacocks vary in size from 2 to 10 inches and are usually placed at a depth of about 8 feet below the water line. In many cases, the storage tanks are located below the water line, and it is possible to fill them by gravity. In other cases, the water is pumped into the tanks by the general service pump. A few vessels are equipped with special pumps used only for handling the fresh water, and in such instances the tanks are filled by these pumps. In the latter case, it is quite common to find special seacocks used only for taking in the drinking water supply.

The drinking water storage tanks are usually placed near the keel of the vessel, although in some cases they are placed on an upper deck. They are constructed of galvanized iron or sheet steel, usually cylindrical in shape, and have capacities varying from 2000 to 10,000 gallons. In a few cases, tanks are built in the fantail of the vessel by placing a bulkhead across the ship and allowing the hull to form a part of the tank. Tanks of this character are more or less liable to contamination. In fact, on two vessels, soil pipes from water closets were found to pass through the tank, and in one case leakage from around the rudder post polluted the drinking water. Very few tanks are lined, though sometimes they are given a coat of "Bitumastic Enamel" or of neat cement.

The water of the Great Lakes contains so little sediment that it is unnecessary to physically clean the tanks except at long intervals. On many freight vessels, it was found to be the custom at frequent intervals for a man to go inside the tanks and scrub them, but it is believed that such cleaning is dangerous, because of the chance of contamination from a possible typhoid carrier. It was recommended that the vessels using this method discontinue it and substitute therefor sterilization of the tank by dosing it with a large amount of calcium hypochlorite.

DISTRIBUTING SYSTEMS

Although on most vessels there are several systems of water supply, the only one of sanitary significance is the fresh or drinking water which supplies drinking fountains, kitchens and lavoratories.

This water is always distributed either by gravity from a storage tank located on the upper deck or by a special distributing pump which maintains a constant pressure in the system. When the tanks are filled by gravity, there is always a special distributing pump (see fig. 2). When the tanks are filled by general service pump, the water is either distributed by gravity or by a special pump (see figs. 3 and 4). When a special pump is used for filling the tank, the water is distributed by this same pump, although in some cases it may supply a gravity tank on the upper deck. The greatest opportunity for the contamination of the drinking water supply occurs when the tanks are filled by the general service pump. This pump is often used for washing down decks while the vessel is lying in port. After leaving port, it is used for shooting ashes and other purposes for perhaps an hour before the drinking water tanks are filled, it being thought that in this time the pump and piping system are thoroughly cleansed and free from contaminating water. When we consider, however, that on some vessels the suction pipe is 8 inches in diameter and perhaps 50 feet long and that the water passes through a manifold system containing numerous bends, it is obvious that there is a considerable opportunity for polluting matter to remain in the piping system and be carried into the drinking water tanks when they are filled (see figs. 5 and 6). In those cases where special pumps are used for filling the tanks, the seacock is often left open all the time and the valve near the pump is opened or closed as water is taken in. This means that while the vessel is lying in dock, polluted water

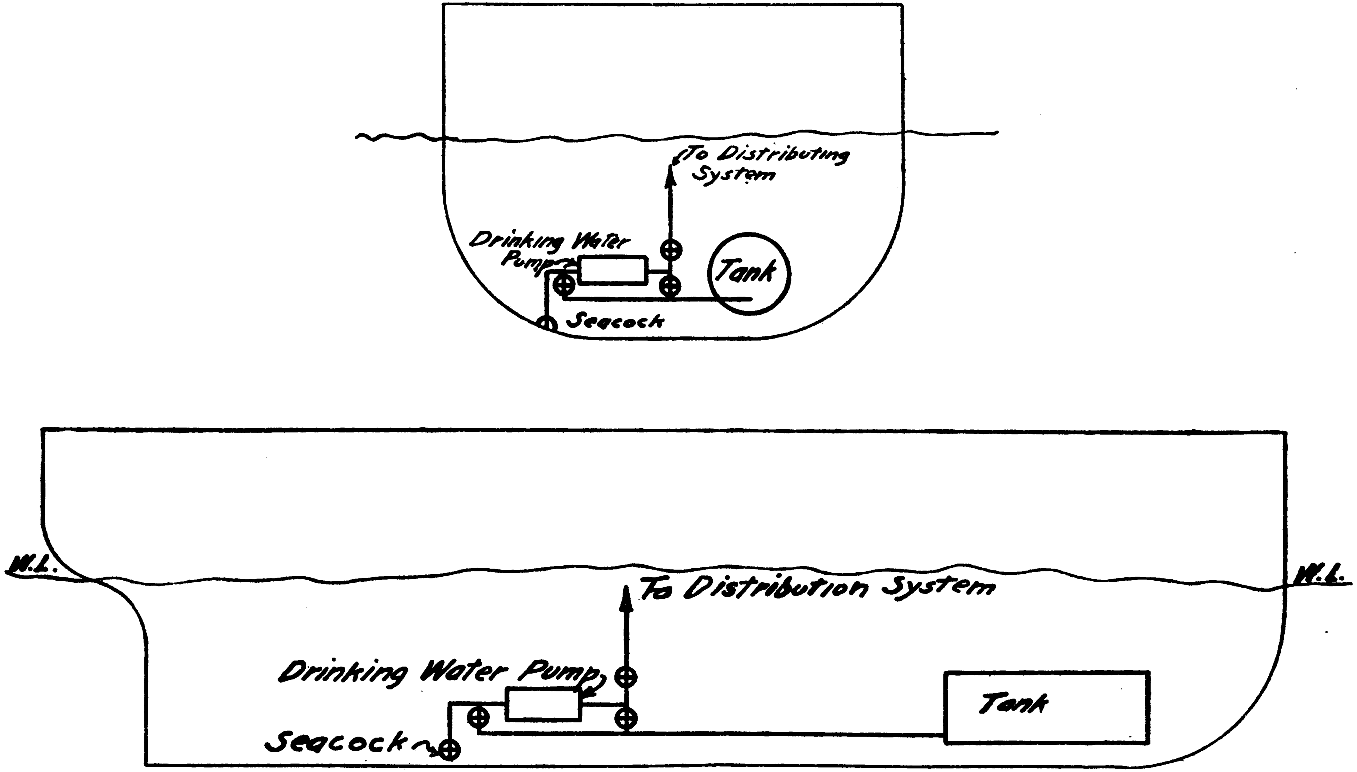

Fig. 2. Tank Filled from Seacock by Gravity or by Special Drinking Water Pump. Water Distributed by Special Drinking Water Pump

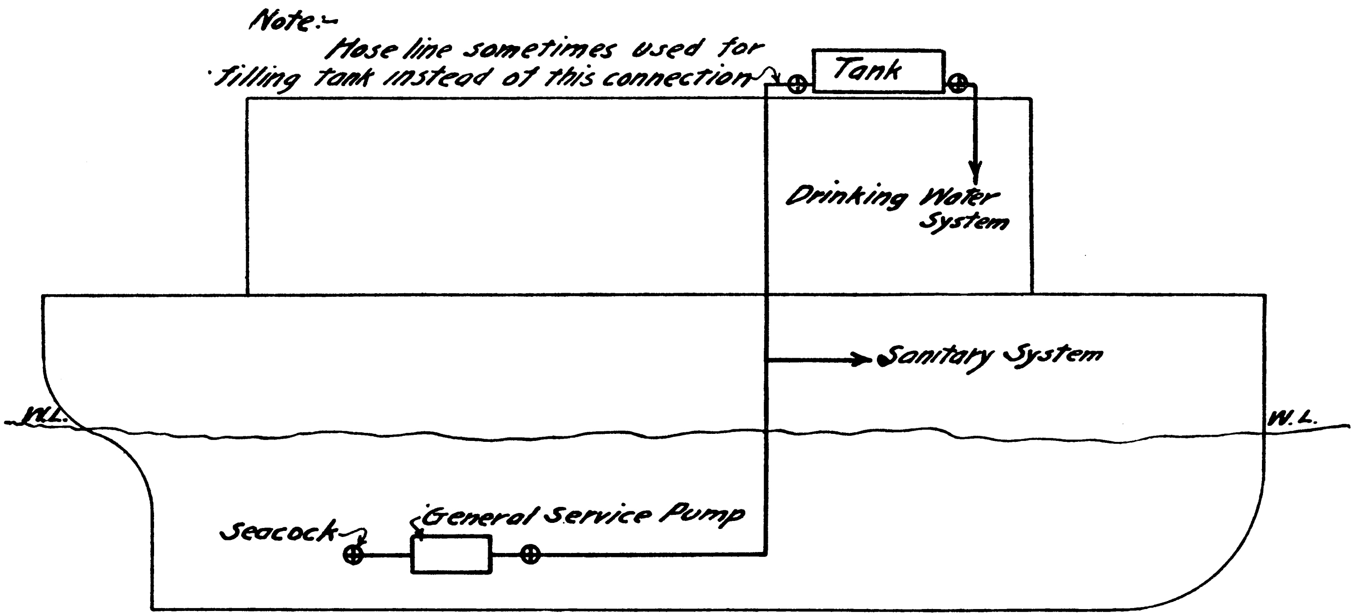

Fig. 3. Tank Filled from Seacock by General Service Pump—Drinking Water Distributed by Gravity

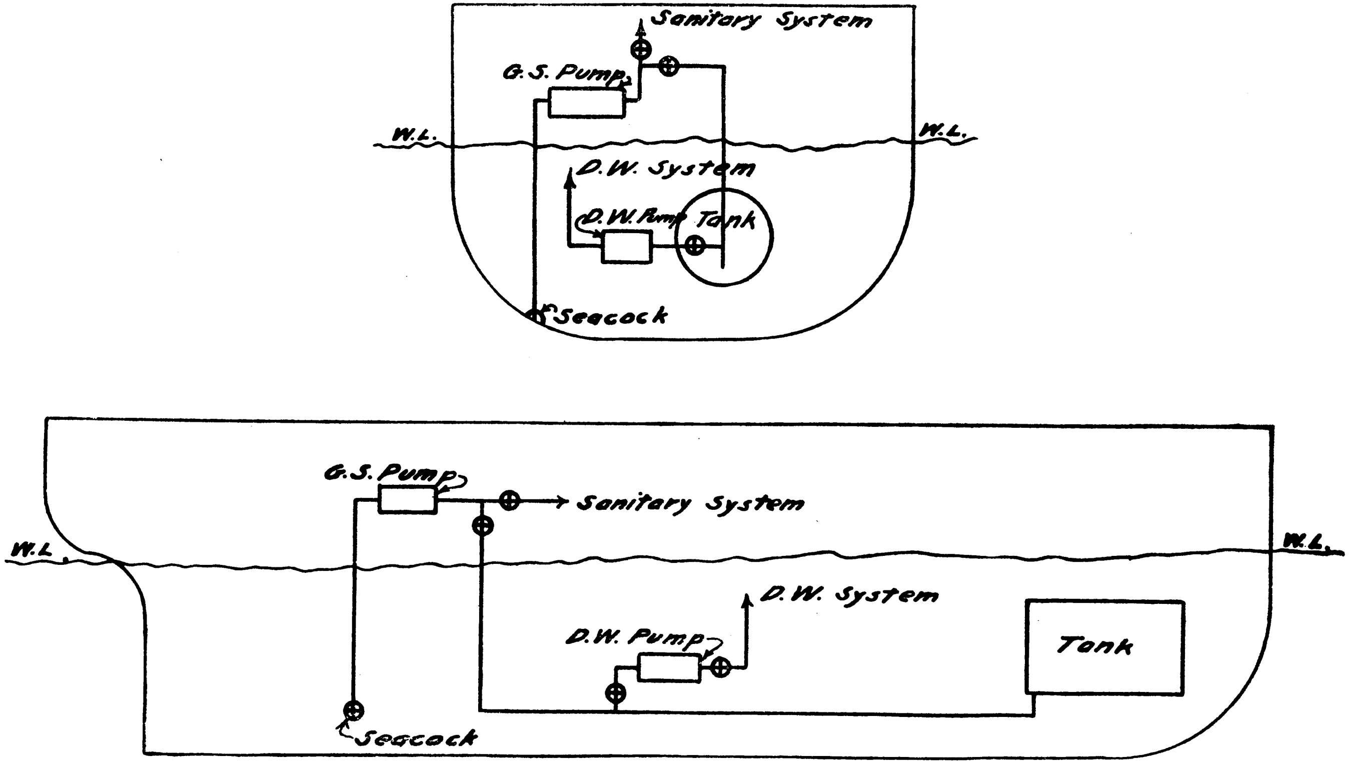

FIG. 4. TANK FILLED FROM SEACOCK BY GENERAL SERVICE PUMP—DRINKING WATER DISTRIBUTED BY SPECIAL PUMP

can enter the seacock and suction line, and upon filling the tanks some of this is carried in. This danger is much aggravated by the fact that at almost every port on the Great Lakes the vessels lie in very badly sewage polluted waters.

On some vessels in order to protect themselves against pollution of this kind, there has been placed between the seacock and the valve near the pump a small drain pipe. With this arrangement, the valve and seacock are kept closed when not taking water from the lake and the drain pipe open, so that if there is any leakage through the seacock it will drain to waste.

Most vessels having a gravity tank on the upper deck, fill it directly from the pump by means of a pipe connection controlled by a valve. On other vessels, the only way to fill the tanks is by means of a hose, which guards against the accidental filling of this tank while lying in port (see fig. 3). That this matter is important is borne out by the fact that at times water is pumped into the tanks when lying at dock. In fact, during one of the inspections made by the writer, a tank of this kind was found filled with Chicago River water due to the carelessness of a watchman in opening the valve leading to the tank, while washing down decks. From statements made by ships' officers, and others, it is evident that occurrences of this kind are by no means rare.

When the drinking water tanks are filled from shore, it is done either by carrying the water through a fire hose directly from the hydrant to the tank or by connecting the hose on to the distribution system. Most vessels which fill their tanks from shore have a connection between the general service pump and the tanks, but in many cases, this connection has been protected from contamination by means of two valves and a drain pipe as described heretofore in connection with seacocks.

OPPORTUNITIES FOR CONTAMINATION

The opportunities for contamination of the drinking water of vessels are:

1. From faulty seating of valves, or failure to close valves while lying in polluted water.

2. Since in most vessels the seacocks are aft of amidships there is a possibility of pumping in fecal matter discharged from toilets near the bow.

3. It is often difficult for a vessel to obtain the necessary amount of drinking water at a sufficient distance from contaminated harbors, and this matter is aggravated by the fact that the engineer can not always tell exactly where a vessel is at any time. There is also the possibility of some accident in the engine room which may cause the engineer to forget to close the seacock as the vessel approaches a polluted harbor.

4. There is also the chance of picking up contamination in the wake of other vessels, or when one vessel is towing another. That this is a real danger has been brought out by testimony before the International Joint Commission.

SUMMARY

As a result of the above statements, it can be seen that it is an impossibility for any vessel operating on the Great Lakes, using the methods at present in vogue, to obtain water absolutely free from contamination. It is therefore necessary, in order to always furnish water of the required purity, for each vessel to be equipped with some suitable form of water purification. Some vessels have already made an attempt along this line, and the apparatus in use will be briefly discussed.

FILTRATION

The most common method used in attempting to purify the drinking water on board vessels is that of filtration through small pressure rapid sand filters, there being about thirty vessels using filters of this kind. These filters are either used as a complete process in themselves or as a preliminary step in some other method of purification. The time will not be taken to discuss the operation of this type of filter as it is generally known that such pressure rapid sand filters using an alum shunt feed box for adding coagulating chemical are very inefficient. A total of 213 tap samples were collected from vessels using small rapid sand filters only, and of this total less than 39 per cent conformed to the standard. Two boats were equipped with rapid sand filters using an electric current for producing a coagulant of iron hydrate, but the results on these boats were no better than on the ordinary type.

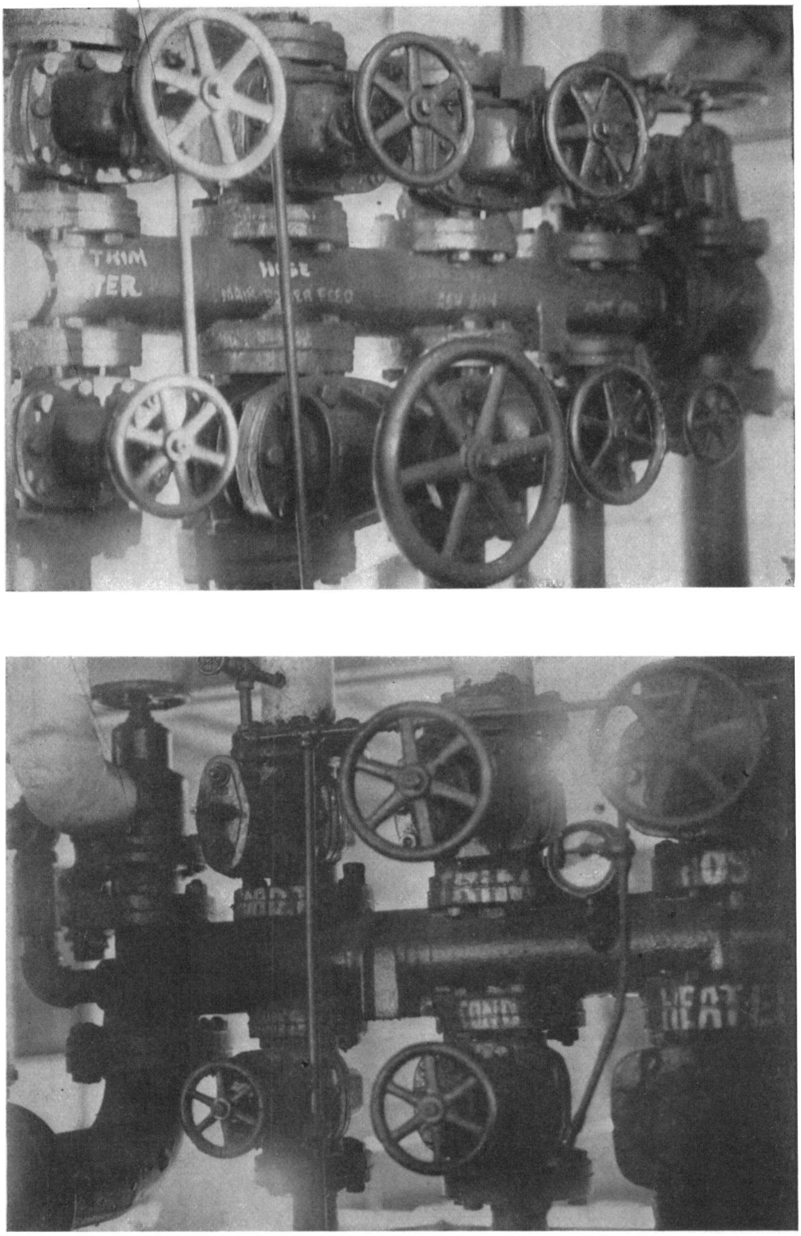

Fig. 5. Photograph of Manifolds on Two Vessels—Lower Photograph Shows Wheel on Valve Controlling Line Leading to Forward Tank Removed—Drain Valve for Detecting Leakage Can Be Seen above this Valve.

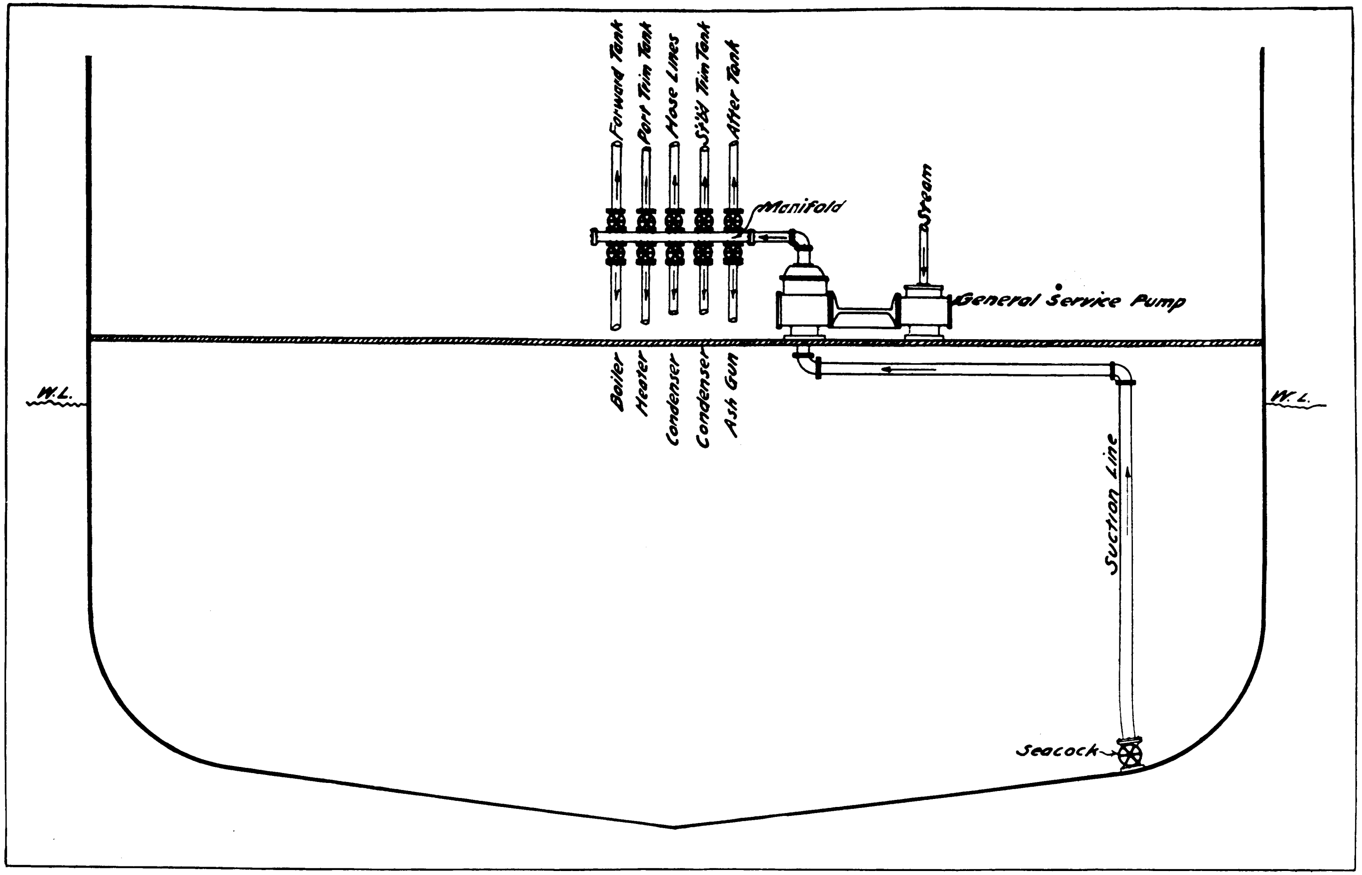

FIG. 6. CROSS SECTION OF VESSEL SHOWING SEACOCK, SUCTION LINE AND MANIFOLD.

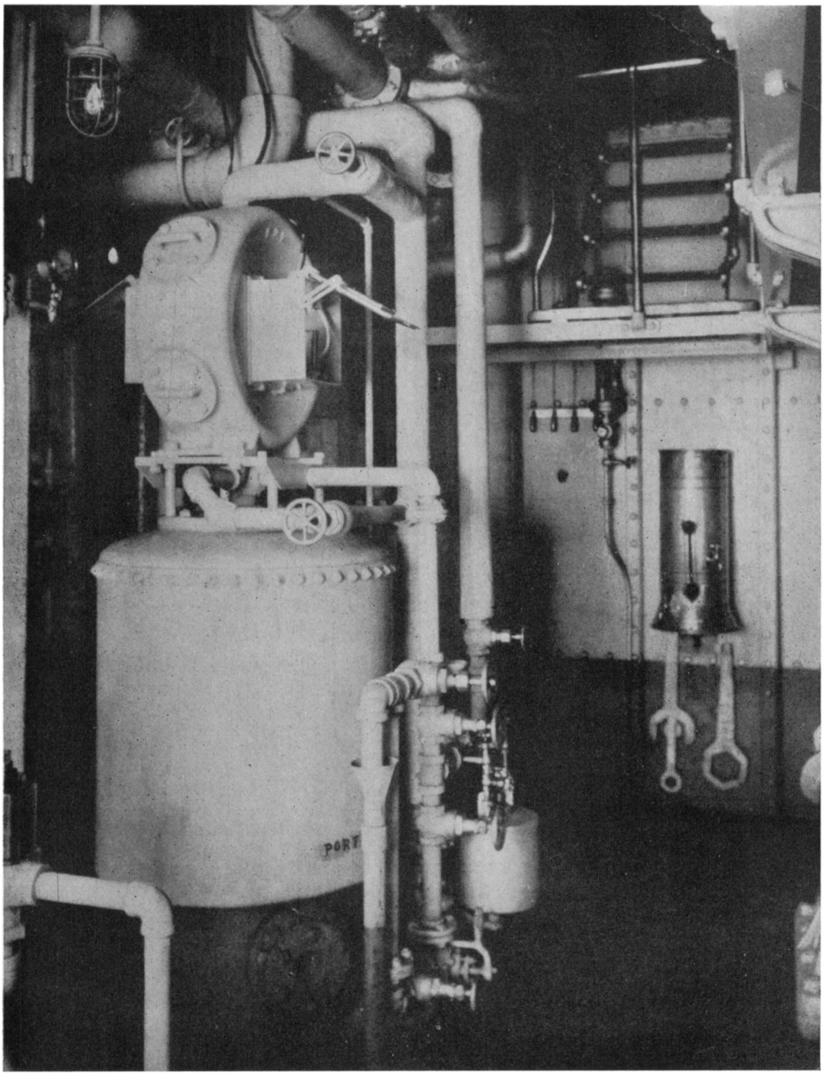

FIG. 7. RAPID SAND PRESSURE FILTER WITH SHUNT FEED COAGULANT BOX AND PRESSURE TYPE ULTRA VIOLET RAY APPARATUS ON STEAMSHIP ALABAMA.

ULTRA VIOLET RAY STERILIZATION

Thirteen vessels were equipped with an apparatus for treating the water with ultra violet rays. In each case, the water was first passed through a rapid sand pressure filter in order to remove any turbidity. Most of the vessels used the pressure type of apparatus in which the water was caused to pass by means of a series of baffles, in thin sheet through the ultra violet rays (see figs. 7 and 8). The lamps for furnishing the rays were mercury vapor lamps of the Cooper-Hewett type constructed of quartz, which allows the passage of the ultra violet rays. These lamps, with one exception, were operated on a current of 110 volts. There were a great many defects in the apparatus as in use during the past summer, but no attempt to enumerate them will be made at this time. Suffice it to say that the company manufacturing this apparatus has as a result of the findings of this laboratory made a considerable number of changes, all of which were for the purpose of increasing the intensity of the light and of making the apparatus absolutely automatic and fool proof in operation (see fig. 9).

CHLORINE DISINFECTION

Five vessels treated their drinking water with calcium hypochlorite by adding a small dose to the storage tanks each time they were filled. Although hypochlorite is an efficient sterilizing agent when properly handled, its use on vessels is not to be recommended, inasmuch as it requires constant supervision for efficient results and since supervision of this kind is not possible on board ship.

On one vessel, there was installed late in the season an apparatus for treating water by means of liquid chlorine. This result was accomplished by making up with the chlorine gas a solution of chlorine water which was fed into the system in proportion to the amount of water being used. The apparatus was quite complicated and somewhat fragile and was broken during a high sea before any reliable conclusions could be drawn as to its efficiency. As a general thing, however, any treatment of this kind, which is dependent for its efficiency upon the human element, is bound to fail at times. The engineer's duty is first to run his engine and the water supply is more or less of a secondary consideration to him and will be neglected in case of unexpected trouble in the engine room.

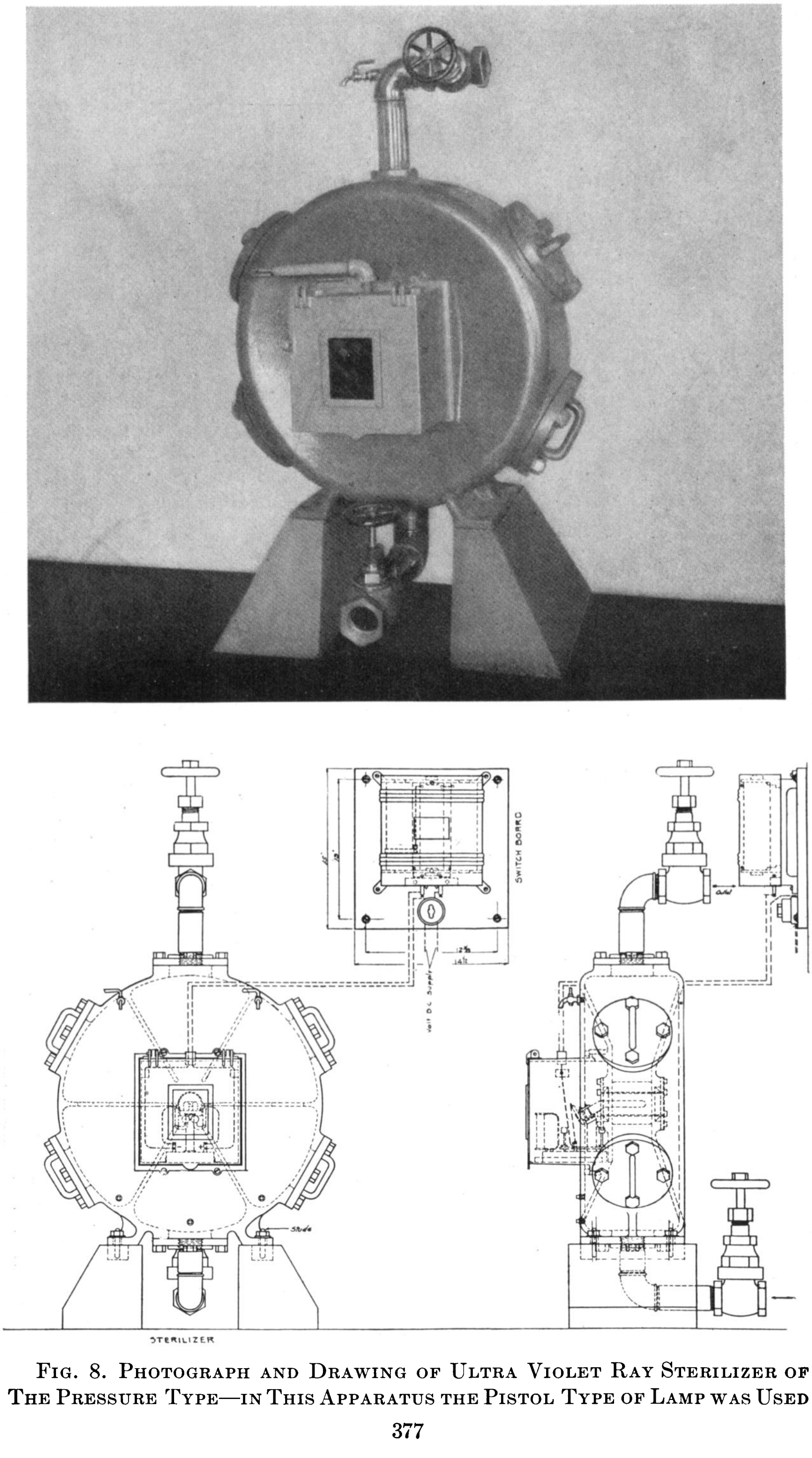

FIG. 8. PHOTOGRAPH AND DRAWING OF ULTRA VIOLET RAY STERILIZER OF THE PRESSURE TYPE—IN THIS APPARATUS THE PISTOL TYPE OF LAMP WAS USED

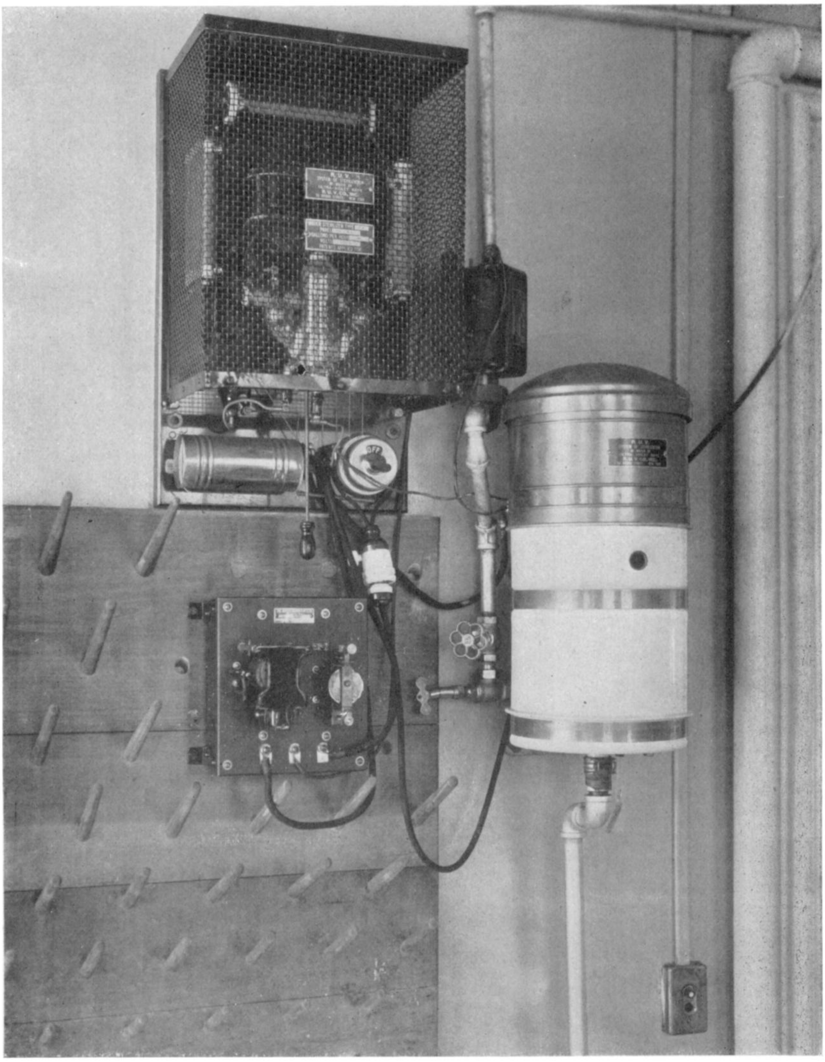

FIG. 9. PHOTOGRAPH OF ULTRA VIOLET RAY STERILIZING APPARATUS OF THE GRAVITY TYPE EQUIPPED WITH AUTOMATIC TILTED LAMP AND SOLENOID OPERATED WATER VALVE SO ARRANGED THAT NO WATER CAN PASS THE APPARATUS UNLESS THE CURRENT IS ON AND THE LAMP AT ITS MAXIMUM INTENSITY.

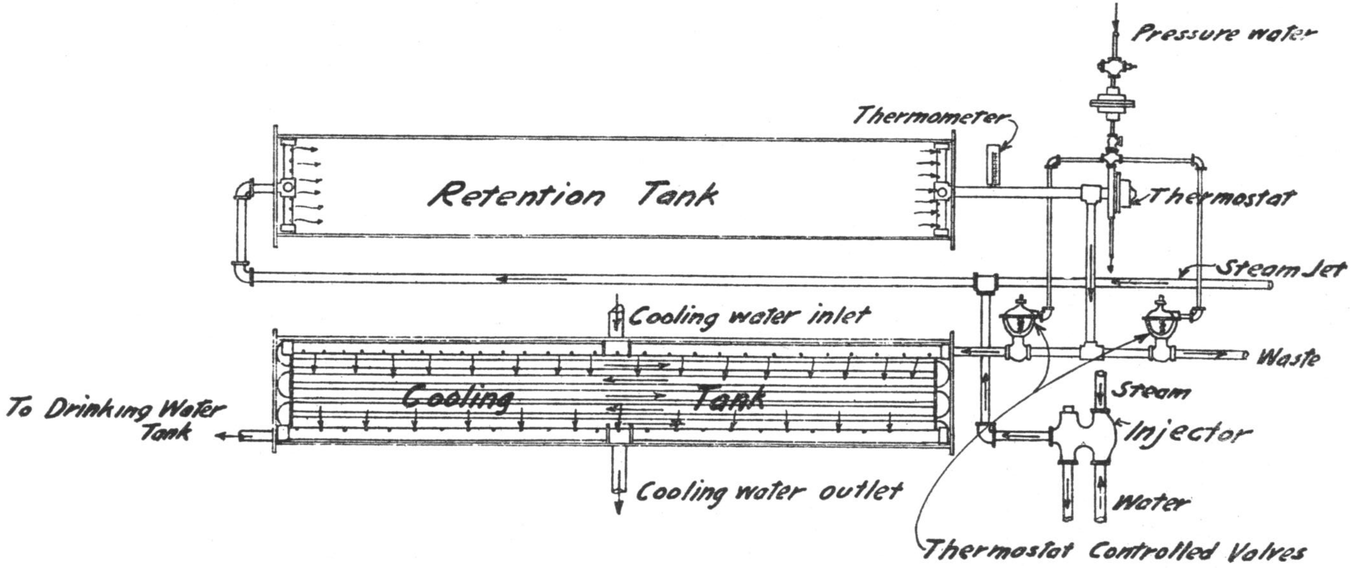

FIG. 10. DIAGRAM OF APPARATUS FOR DISINFECTING WATER BY STEAM JET EQUIPPED WITH DEVICES TO MAKE IT AUTOMATIC AND FOOL-PROOF IN OPERATION

STERILIZATION BY HEAT FROM STEAM JET

Five vessels treated their water by heating it with a steam jet. In this apparatus the water was first pumped through a seacock with a steam injector, after which a steam jet was added, increasing the temperature of the water to around 220°F. After reaching this temperature, the water was passed through a coil around which was circulated cold water, which cooled the drinking water down to about 130°F., after which it was run to the storage tanks. The results of this apparatus, so far as B. coli were concerned, were good, but due to the fact that the water ran to the storage tanks at a high temperature aftergrowths took place, which often gave extremely high counts on agar at 37°C. In order to produce efficient results, it was necessary for the engineer to carefully watch the apparatus while taking water in to see that none which was not heated to the requisite temperature reached the storage tanks. With a few modifications, the apparatus could be made fool proof and automatic in operation (see fig. 10). These improvements would consist of adding a supplementary tank between the injector and the cooling tank, which would retain the water at its maximum temperature for perhaps five minutes. At the outlet of this retention tank would be placed a thermostat, which would automatically operate a waste valve and the valve leading into the cooling tank, so that when the water was not up to the requisite temperature it would be run to waste.

SUMMARY OF BACTERIOLOGICAL RESULTS

A total of about 1000 samples were collected and examined from 74 passenger vessels and 68 samples were collected and examined from 33 different freight vessels. A series of vessels equipped with various types of purification apparatus were selected for intensive study. From these vessels samples were collected from many points in the purification systems in order to determine their efficiency.

A total of 155 tap samples were collected from passenger vessels having no form of treatment. About 22 per cent of these samples conformed to the standard. A total of 521 tap samples were collected from vessels having treatment and about 40 per cent of these conformed to the standard. From freight vessels, all of which were without treatment, 57 samples were collected, of which about 19 per cent conformed to the standard. Of the two most common methods of purification, rapid sand pressure filters and ultra violet light, in each case less than 39 per cent conformed to the standard (see figs. 11 and 12).

CONCLUSIONS

From the foregoing, the following conclusions are derived:

1. The type and location of seacock and the arrangement for filling the tanks play but a small part in the character of the water obtained.
2. The types of purification apparatus in use on vessels of the Great Lakes at the present time are woefully inefficient. There is not a method in use that can be depended upon to deliver a safe water at all times.
3. The route of the vessel plays some part in the character of the water supply, especially because of the places of docking.
4. It is an impossibility to obtain a drinking water for boats directly from the lakes that will at all times conform to the Treasury Department standard.

Therefore, it is necessary that every vessel on the Great Lakes, in order to comply with the law, install a form of water purification apparatus, which shall be so constructed that it cannot under any conceivable circumstance deliver a water which will not conform to the government requirements. This will necessitate an apparatus that will be entirely automatic in action and which will not depend for its efficiency upon the human agency.

Undoubtedly, the ideal form of water purification apparatus which will meet the above requirement is the still. Steam heated water stills are now on the market that are absolutely automatic in action and impossible of producing any water except that which is bacteriologically pure. Stills are in use at the present time on practically all ocean going vessels, and there is no reason why they are not applicable for lake vessels. A big advantage of stills is that no attention need be paid to the place of taking water and the stills can operate twenty-four hours a day. There are only three disadvantages of stills, and these are not of sanitary significance. They are the operating cost, the possibility of corrosion of pipes or tanks, and the possibility of producing a flat or unpalatable water.

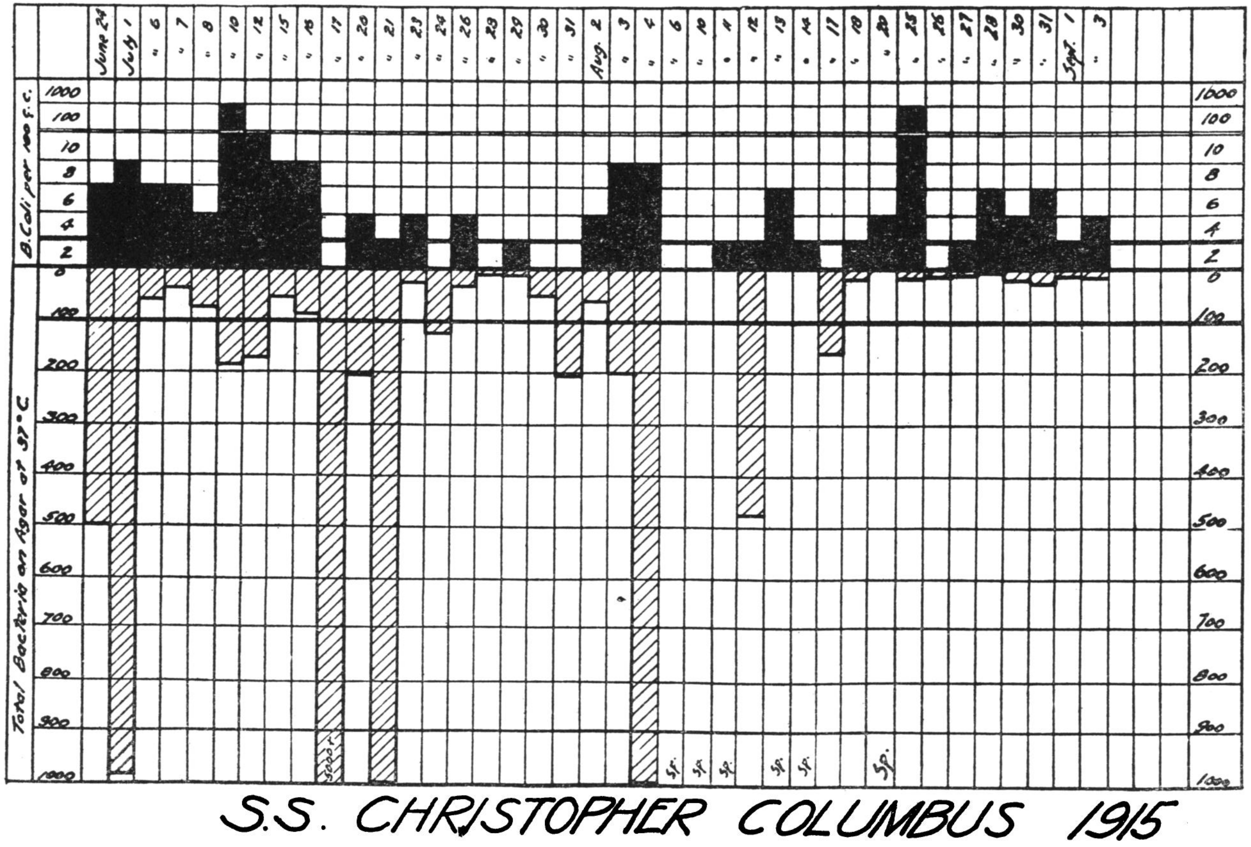

FIG. 11. GRAPHICAL CHART SHOWING RESULTS OF ANALYSES OF TAP SAMPLES FROM STEAMSHIP "CHRISTOPHER COLUMBUS"—THESE RESULTS ARE TYPICAL OF SIMILAR VESSELS

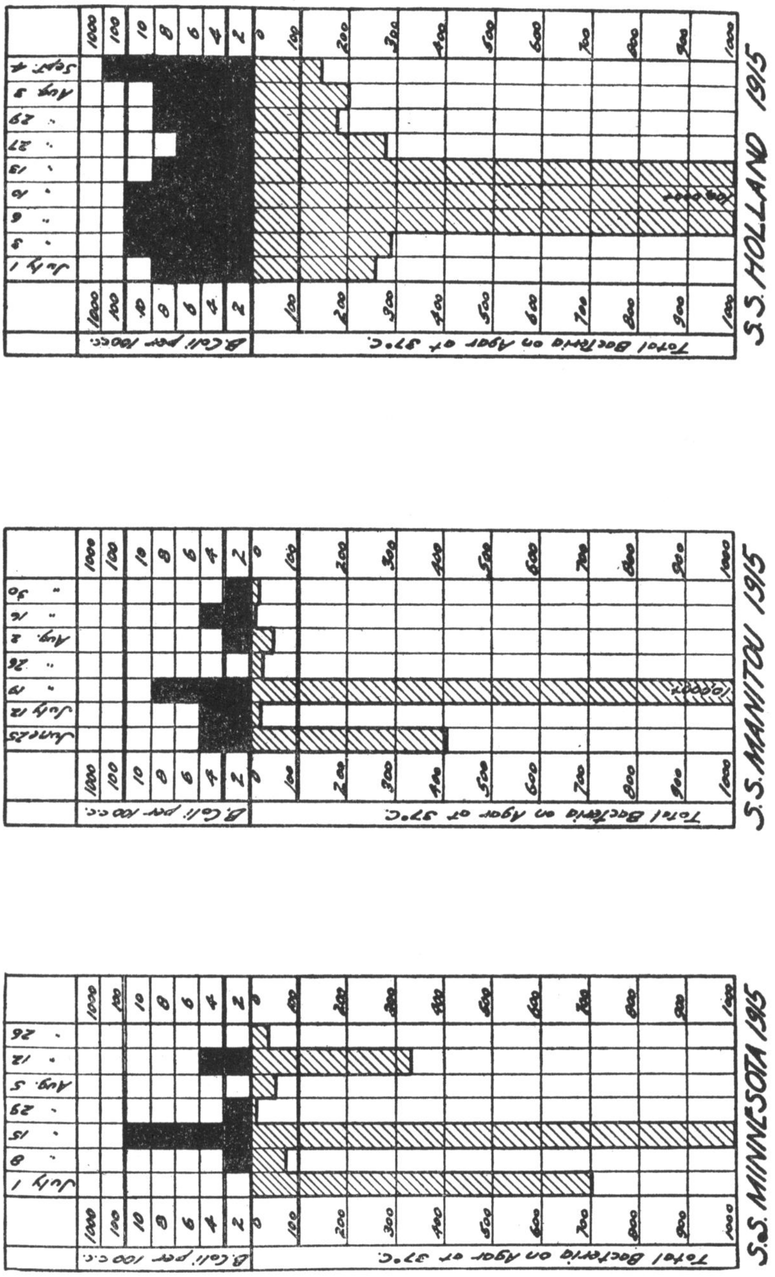

FIG. 12. GRAPHICAL CHART SHOWING RESULTS OF ANALYSES OF TAP SAMPLES FROM STEAMSHIPS "MINNESOTA," "MANITOU" AND "HOLLAND"—ALL THESE VESSELS WERE EQUIPPED WITH RAPID SAND PRESSURE FILTERS ONLY

The scheme heretofore outlined of pumping water by means of an injector would also be perfectly reliable and would produce a palatable water which would meet the requirements, without excessive cost.

Tests now being carried on at the laboratory indicate that the ultra violet ray apparatus with devices to prevent overloading and to prevent any water passing into the distribution system when the light is not at its maximum intensity will also give satisfactory results.

Outside of the above three methods, there are, in their present state of development, none which will under all circumstances produce a water meeting the government requirements.